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(54) **METHODS FOR REDUCING OPERATIONAL LATENCY OF DATA STORAGE SYSTEMS**

(71) Applicant: **Western Digital Technologies, Inc.**, Irvine, CA (US)

(72) Inventors: **Scott Burton**, Westminster, CO (US); **Asif F. Gosla**, Irvine, CA (US)

(73) Assignee: **Western Digital Technologies, Inc.**, Irvine, CA (US)

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CPC ***G11B 20/1889*** (2013.01); ***G11B 5/09*** (2013.01); ***G11B 20/1217*** (2013.01); *G11B 2020/1232* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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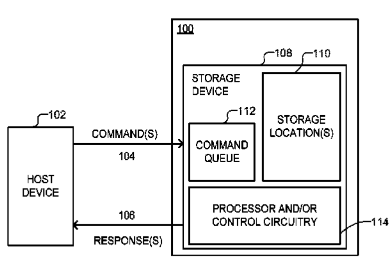
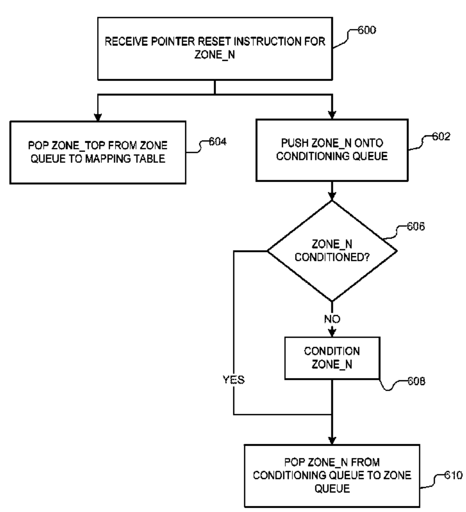
(57) **ABSTRACT**

Systems and methods for reducing operational latency of data storage systems are disclosed. More particularly, a data storage device can perform conditioning operations on inactive zones while the data storage device is idle. When an active zone is the target of a write command, the data storage device can exchange a conditioned inactive zone for the unconditioned target zone. The write operation can be performed immediately on the previously-inactive already-conditioned zone. At a later time, the target zone can be conditioned.

20 Claims, 7 Drawing Sheets





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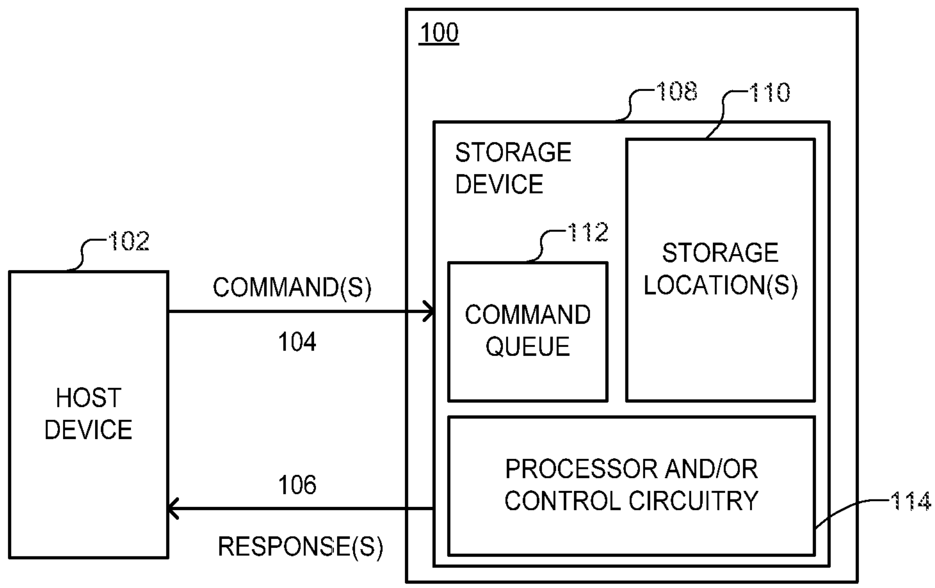

100
108
110
STORAGE DEVICE
STORAGE LOCATION(S)
102
112
COMMAND(S)
COMMAND QUEUE
104
HOST DEVICE
PROCESSOR AND/OR CONTROL CIRCUITRY
106
114
RESPONSE(S)

FIG. 1

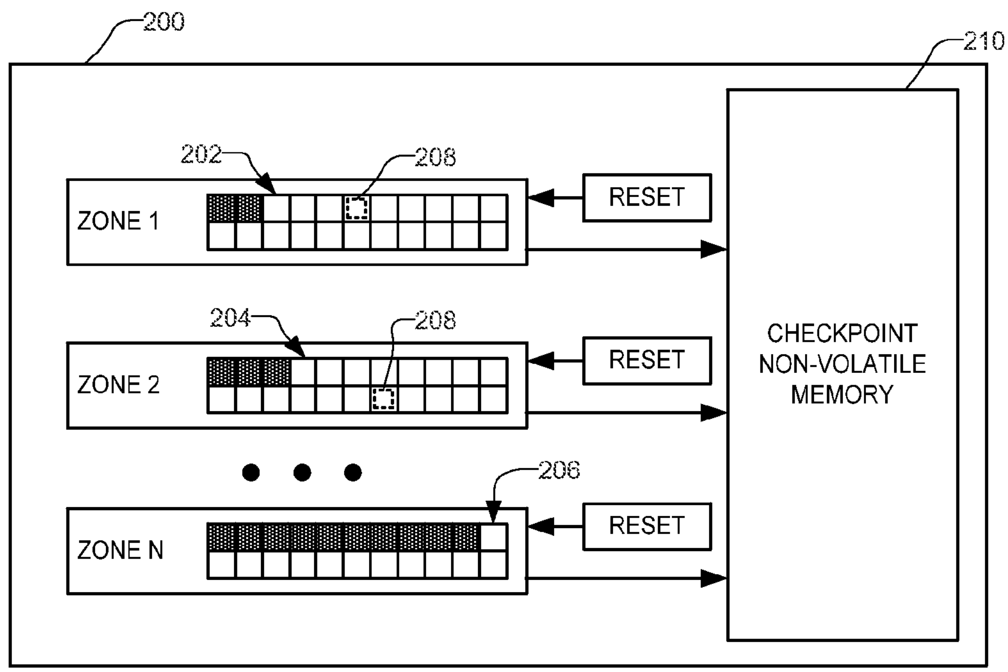
200
210
202
208
ZONE 1
RESET
204
208
ZONE 2
RESET
CHECKPOINT
NON-VOLATILE
MEMORY
206
ZONE N
RESET

FIG. 2

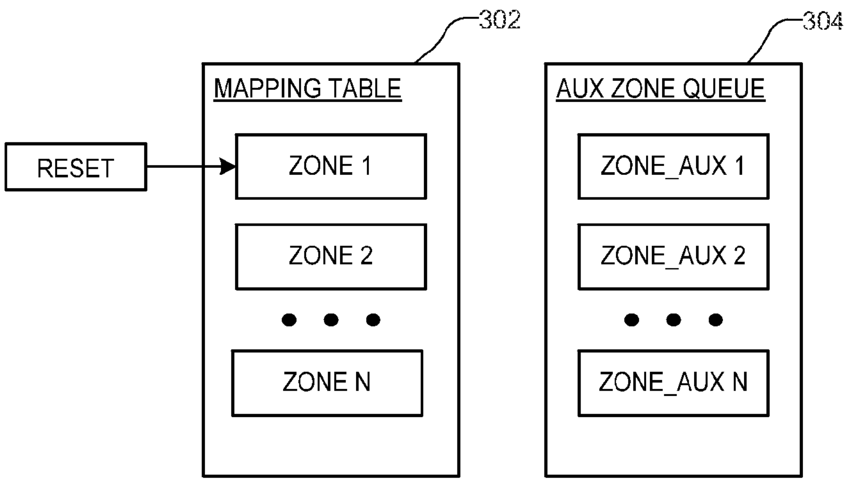

FIG. 3A

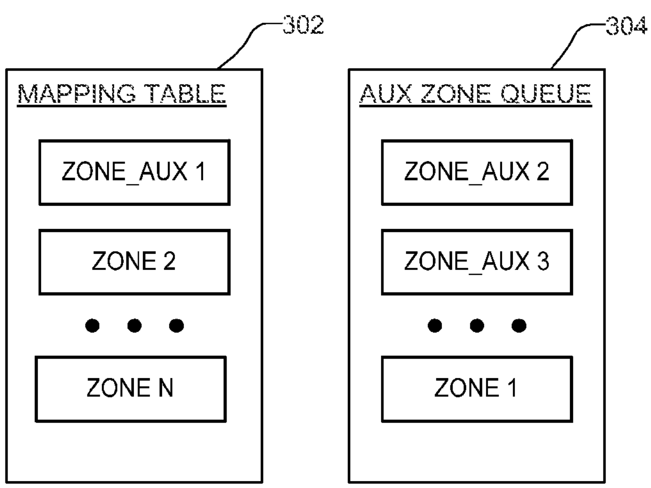

FIG. 3B

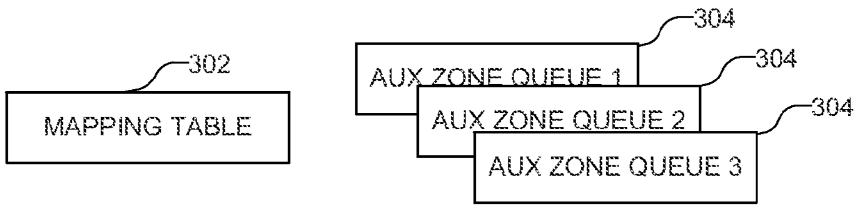

FIG. 3C

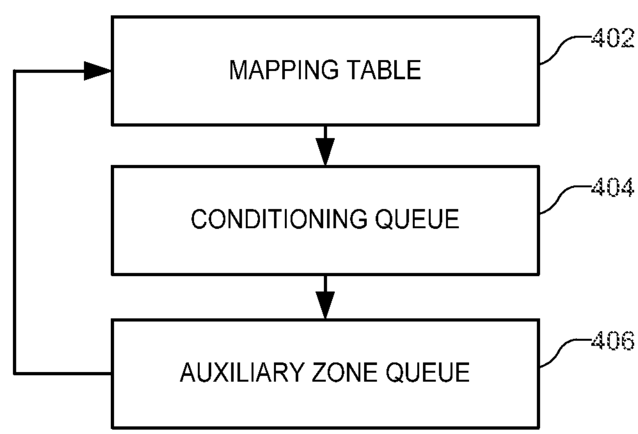
MAPPING TABLE
402
CONDITIONING QUEUE
404
AUXILIARY ZONE QUEUE
406

FIG. 4

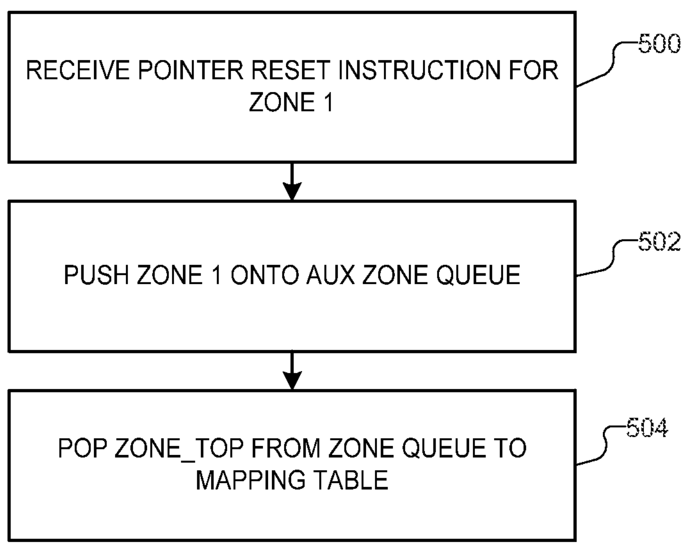
RECEIVE POINTER RESET INSTRUCTION FOR ZONE 1
500
PUSH ZONE 1 ONTO AUX ZONE QUEUE
502
POP ZONE_TOP FROM ZONE QUEUE TO MAPPING TABLE
504

FIG. 5

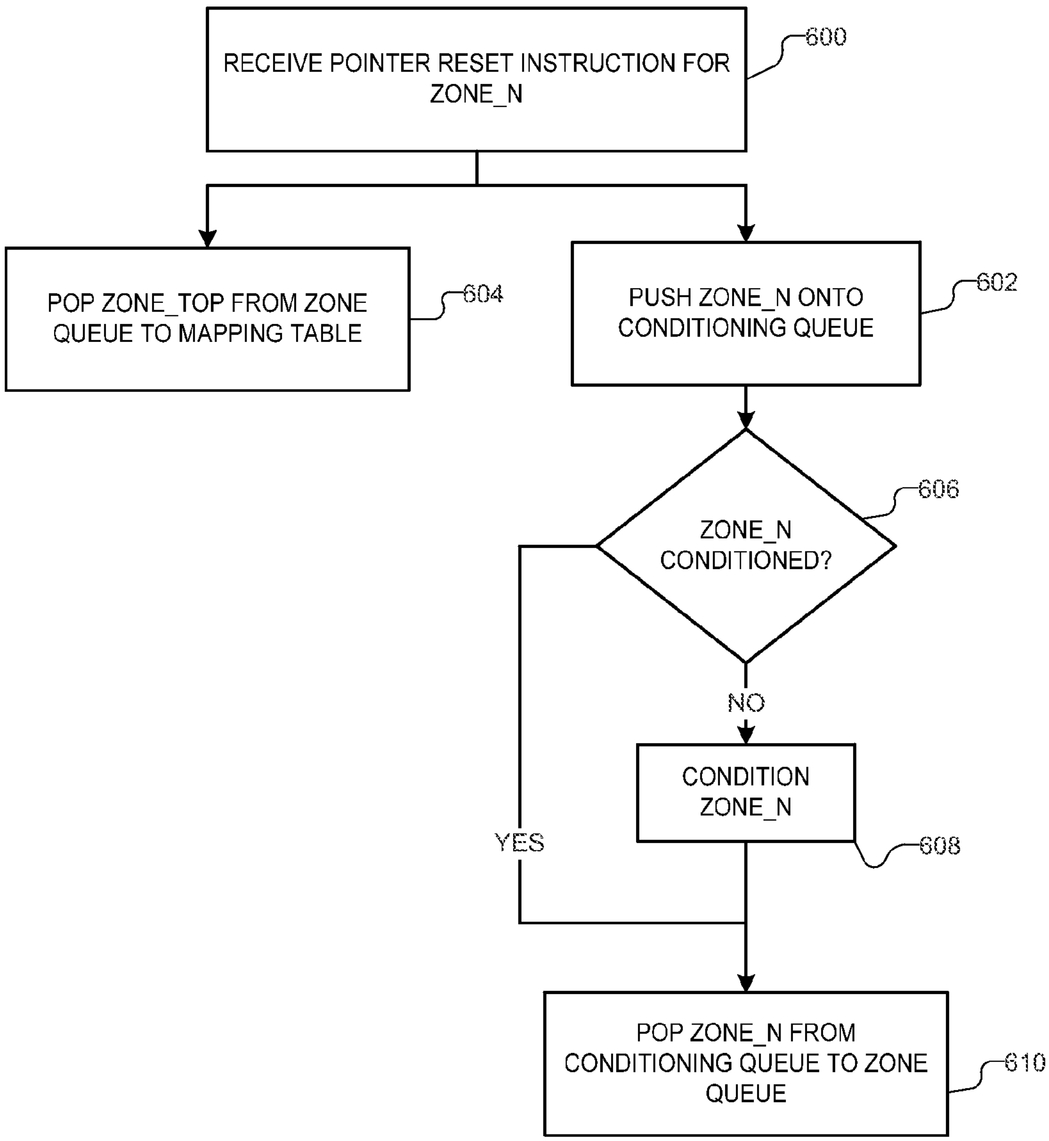
RECEIVE POINTER RESET INSTRUCTION FOR ZONE_N
600
POP ZONE_TOP FROM ZONE QUEUE TO MAPPING TABLE
604
PUSH ZONE_N ONTO CONDITIONING QUEUE
602
ZONE_N CONDITIONED?
606
NO
YES
CONDITION ZONE_N
608
POP ZONE_N FROM CONDITIONING QUEUE TO ZONE QUEUE
610

FIG. 6

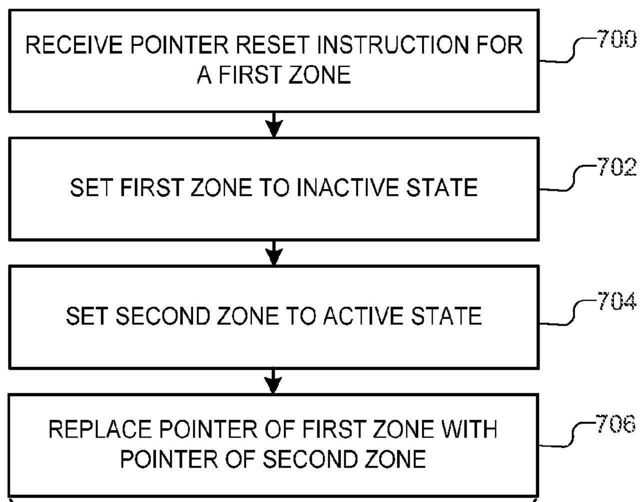
RECEIVE POINTER RESET INSTRUCTION FOR A FIRST ZONE
700
SET FIRST ZONE TO INACTIVE STATE
702
SET SECOND ZONE TO ACTIVE STATE
704
REPLACE POINTER OF FIRST ZONE WITH POINTER OF SECOND ZONE
706

FIG. 7A

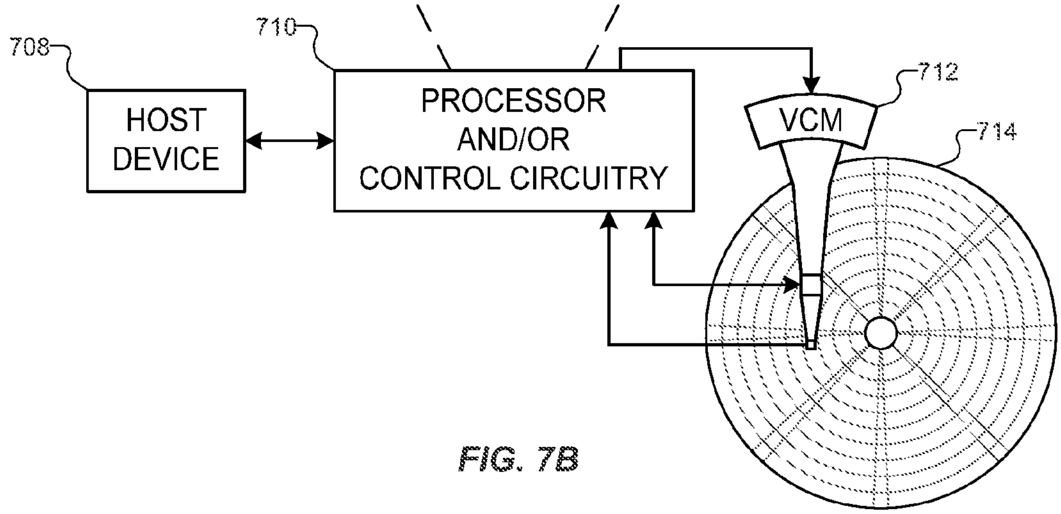
708
HOST DEVICE
710
PROCESSOR AND/OR CONTROL CIRCUITRY
712
VCM
714

FIG. 7B

METHODS FOR REDUCING OPERATIONAL LATENCY OF DATA STORAGE SYSTEMS

TECHNICAL FIELD

This disclosure relates to information storage and, more particularly, to systems and methods for reducing operational latency of data storage systems.

BACKGROUND

Many computing systems generate or receive data that may be desirable to store persistently. These computing systems often utilize a data storage device, such as a hard disk drive ("HDD"), for data storage and retrieval. In many cases, a HDD can include a circular recording disk made from a magnetic material onto (and/or into) which data can be recorded as patterns of magnetic polarity. A write head of the HDD can write data to the recording disk in response to a write instruction, and a read head can retrieve data from the recording disk in response to a read instruction.

A HDD may perform certain tasks upon each read or write instruction as a result of a particular magnetic recording implementation. For one example, a data storage device can implement shingled magnetic recording ("SMR") to increase the data density of the recording disk. For example, an SMR data storage device can write data in tracks that partially overlap radially and/or circumferentially. Accordingly, in part as a result of the overlap of SMR tracks, an SMR data storage device can overwrite data tracks adjacent to the written data track during a write operation. Accordingly, many SMR data storage devices write data sequentially, and data may be organized into to one or more zones.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made to representative embodiments illustrated in the accompanying figures. It should be understood that the following descriptions are not intended to limit the disclosure to one preferred embodiment. To the contrary, each is intended to cover alternatives, modifications, and equivalents as may be included within the spirit and scope of the described embodiments as defined by the appended claims.

FIG. **1** depicts a simplified block diagram of an example data storage system that may be configured to perform one or more maintenance and/or conditioning operations prior to writing.

FIG. **2** depicts a simplified block diagram of an example SMR data storage system implementing multiple zones separated by guard bands.

FIG. **3**A depicts a simplified block diagram of an example SMR data storage system implemented with auxiliary zones.

FIG. **3**B depicts the example SMR data storage system of FIG. **3**A after the data storage system receives a write pointer reset instruction.

FIG. **3**C depicts a simplified block diagram of an example SMR data storage system implemented with multiple auxiliary zone queues.

FIG. **4** depicts a flow chart of sample operations of a method of operating an SMR data storage system implemented with auxiliary zones.

FIG. **5** depicts a flow chart of sample operations of another method of operating an SMR data storage system implemented with auxiliary zones.

FIG. **6** depicts a flow chart of sample operations of another method of operating an SMR data storage system implemented with auxiliary zones.

FIG. **7**A-**7**B depicts a flow chart of sample operations of another method of operating an SMR data storage system implemented with auxiliary zones.

The use of the same or similar reference numerals in different drawings indicates similar, related, or identical items where appropriate.

DETAILED DESCRIPTION

Embodiments described herein relate to systems and methods for decreasing the operational latency of data storage systems implementing shingled magnetic recording, although the various systems and methods described herein are not limited to particular form factors and can apply equally to magnetic or non-magnetic data storage system types. Further, it should be appreciated that the various embodiments described herein, as well as functionality, operation, components, and capabilities thereof may be combined with other elements as necessary, and so any physical, functional, or operational discussion of any element or feature is not intended to be limited solely to a particular embodiment to the exclusion of others.

Many embodiments described herein take the form of a data storage system that performs various maintenance operations to physical sections of a magnetic recording disk. A variety of maintenance operations (such as block, zone, and/or sector conditioning, managing relocation lists, facilitating discovery of write pointer locations, etc.) can be performed as initialization operations (for example on power up) to minimize writing to physically defective sectors. For example, in certain embodiments, a zone conditioning operation can include writing a particular pattern to one or more blocks within a particular zone of the data storage system. Thereafter, the pattern may be read back by the data storage system. The written and read patterns can be compared to determine whether the data was written correctly. In the event that the patterns do not match, the data storage system may attempt to write the pattern again. If the patterns do not match for subsequent write/read comparisons, the data storage system can conclude that a physical defect is present. The data storage system can note the location of the physical defect so as to avoid writing to that location during future write operations.

In other examples, a zone conditioning operation can include writing a known pattern or applying a known signal one or more times to one or more blocks of a particular zone so as to normalize the magnetic polarity of the various blocks within the zone. For example, an alternating current signal ("AC") can be applied at a particular frequency to various blocks of a selected zone as a write operation. In this manner, the operation can have the effect of securely erasing old data before new data is written. Accordingly, the conditioning operation of applying an AC signal at a selected frequency to erase one or more blocks of a particular zone is referred to herein as an "AC erase" operation.

In still further examples, a zone conditioning operation can include reading data currently stored within a zone. For one example, as noted above, a data storage device can implement SMR to increase the data density of the recording disk. Upon receiving a write instruction to a specific zone, an SMR data storage device may condition the zone by first reading the entire zone (or a portion of the zone) into a separate memory location such as a data buffer. In this manner, the data stored within the zone is not lost as a result of the SMR write operation.

In still further examples, a zone conditioning operation can include determining a safe write location within the data storage system as an initialization operation performed on power up. For example, certain data storage systems may only write data sequentially (e.g., SMR data storage systems). In such systems, a non-volatile memory within the data storage system can maintain a table or database of pointers to safe write locations. For example, the non-volatile memory can store a pointer to the last block that contains data within a particular zone. In this manner, when the data storage system next receives an instruction to write to that zone, the non-volatile memory can be queried to retrieve the appropriate write pointer. Thereafter, the data storage system can write data sequentially from the retrieved write pointer. Once the data write operation is complete, the non-volatile memory can be updated to include a new write pointer for the particular zone.

However, in certain cases, a write pointer may not be properly updated. For example, if the data storage device loses power during a write operation, the non-volatile memory may not be updated. In such examples, if the data storage system attempts to write to a zone based on the write pointer retrieved from the non-volatile memory, data can be overwritten and permanently lost. Accordingly, certain sequential data system embodiments described herein, including SMR data storage systems, can include a conditioning operation to facilitate the discovery and/or verification of the location of a write pointer within a particular zone when the data storage device powers up after a power loss. In one embodiment, the conditioning operation can include reading data from that zone until a block is encountered that does not contain data.

Furthermore, in some cases, a sequential data system can receive a write-pointer reset command for a particular zone. In response to the write pointer reset command, the sequential data system can set that zone's write pointer back to the first block of the zone. In these examples the sequential data system may perform one or more conditioning operations prior to writing data at the newly-reset write pointer in order to, for example, discover defects on the magnetic recording disk, write a known pattern to facilitate discovery of write pointer locations, perform an AC erase operation, and so on.

However, although zone conditioning may improve the reliability of certain data storage systems (e.g., AC erase, facilitation of write pointer discovery, and so on), such conditioning operations typically are high latency operations. In other words, although data may be more reliably stored as a result of conditioning, the time required to condition a zone and then write to the zone may be undesirable for certain data storage devices.

Accordingly, embodiments described herein relate to systems and methods for reducing operational latency of data storage systems that may be configured to perform one or more maintenance and/or conditioning operations.

For example, many embodiments include a data storage system having an inactive zone configured to be substituted for an active zone upon receiving an instruction from a host device (such as a computing system) to reset of the write pointer of the active zone. In these examples, the inactive zone may already be conditioned for writing data. In this manner, once the inactive zone is substituted for the active zone, write operations can be performed on the previously-inactive and already-conditioned zone immediately. Sometime later, for example while the data storage system is idle, one or more conditioning operations can be performed on the previously-active zone, as a background task for example. In this manner, from the perspective of the host device, write operations following write pointer reset commands occur immediately whereas conditioning operations occur in a manner that is transparent to the host device. In an alternative non-limiting phrasing, the data storage system of certain embodiments accelerates the performance of write operations by delaying the performance of conditioning operations.

In some embodiments, a data storage system can be implemented with a plurality of auxiliary zones. For example, a data storage system can include a magnetic recording disk divided into ten writeable zones. These zones can be organized into six 'active' zones and four auxiliary 'inactive' zones. When the data storage system receives a write pointer reset instruction to one of the six active zones, the data storage system can substitute one of the four inactive zones with the active zone to be written. Thereafter, the status of the substituted zones can be toggled; the previously-inactive zone can be set to an 'active' status and the previously-active zone can be set to an 'inactive' status.

In many examples, each zone of a data storage system can be associated with a unique address. In some embodiments, the address for a particular zone can be implemented as a pointer to a particular physical location along a magnetic recording disk. In these embodiments, the operation of substituting an active zone with an inactive zone can be performed by substituting the addresses and/or pointer of each respective zone.

Continuing the ten-zone example presented above, the data storage system can internally address the ten zones as zones 1-10. The six active zones can be reported to the host device as writable zones A-F. For example, if zones 1-6 are 'active' and zones 7-10 are 'inactive', the data storage system can associate the address of zone 1 with zone A, the address of zone 2 with zone B, and so on. In this manner, if the host device provides an instruction to read data from zone A, the data storage system can read from zone 1, if the host device provides an instruction to read data from zone B, the data storage system can read from zone 2, and so on.

Accordingly, for many embodiments described herein, when the host device provides an instruction to write to zone A, the data storage system can replace the address of zone 1 with the address of an inactive zone such as, in this example, zone 7. Thereafter, the data storage system can write to zone 7 in response to the write instruction to zone A. Next, the data storage system can report to the host device that the write operation to zone A is commenced. As a result of this operation, zone 7 may be set to 'active' status and zone 1 may be set to 'inactive' status. In this manner, if the host device subsequently provides an instruction to read data from zone A, the data storage system can read from zone 7.

In certain some embodiments, a data storage system can have a number of inactive zones organized as a queue. When idle, the data storage system can perform conditioning operations on the inactive zones within the queue. In one example, the data storage system can condition the inactive zones in a first-in-first-out order. In these embodiments, when the data storage system receives a write instruction to an active zone, the active zone can be pushed onto the inactive zone queue while an inactive zone (that is already conditioned) can be popped from the inactive zone queue and substituted for the previously-active zone. The data storage system can thereafter perform the write operation to the previously-inactive zone. In still further examples, more than one zone queue can be used.

In some embodiments, the number of active and inactive zones can vary. For example, one may appreciate that the greater the number of inactive zones, the faster data may be written. In other words, continuing the example above, if a host device submits an instruction to write data to zones A-E, an implementation with at least five 'inactive' zones may be suited to execute the five write operations faster than an implementation with only four 'inactive' zones. In other words, the implementation with four 'inactive' zones may need to condition one zone prior to writing zone E.

In further embodiments, the number of active and inactive zones can dynamically vary based on one or more parameters. For example, a data storage system storing a small amount of data may set a larger number of zones 'inactive' than a data storage system storing a large amount of data. As the data storage system stores more and more data, it may dynamically reduce the number of 'inactive' zones. In other words, certain data storage systems can set the number of 'inactive' zones based on the amount of data stored within the data storage system.

In some embodiments, a data storage system can set the number of 'inactive' zones based on a measured, predicted, estimated, or determined write throughput. For example, if a large amount of data is expected to be written, the data storage system may increase the number of 'inactive' zones. In another example, if a small amount of data is expected to be written, the data storage system may decrease the number of inactive zones.

In some embodiments, a host device can set or influence the number of active and inactive zones.

FIG. **1** depicts a simplified block diagram of an example data storage system that may be configured to perform one or more maintenance and/or conditioning operations. The data storage system **100** can be configured to communicate with a host device **102**. The host device **102** may be any suitable electronic device such as a laptop computer, desktop computer, server, cellular phone, tablet computer, and so on. In some embodiments, the host device **102** can be implemented as a system of individual electronic devices, for example, as a network of servers.

The host device **102** can send commands **104** to the data storage system **100**. The commands **104** can be any number of suitable commands including, but not necessarily limited to, write commands, erase commands, and read commands. Upon receiving a command **104**, the data storage system **100** may return a response **106**. For one example, if the host device **102** sends a read command **104** the data storage system **100** can send a response **106** including the requested data.

The data storage system **100** can include a storage device **108**. In many examples, the storage device **108** can implement SMR within a storage location **110**. For example, the storage location **110** can include one or more circular recording disks made from a magnetic material onto (and/or into) which data can be recorded as patterns of magnetic polarity.

A write head (not shown) of the storage device **108** can write data to specific regions (or zones) of the recording disk in response to a write instruction from the host device **102**, and a read head (not shown) can retrieve data from the storage device **108** in response to a read instruction from the host device **102**. In an SMR implementation, independent zones can be separated by guard bands of a particular size.

The storage device **108** can also include a memory for storing commands **104**. For example, in certain embodiments, the storage device **108** may include a command queue **112**. The command queue **112** can receive commands **104** from the host device **102** and can execute the commands in a first-in-first-out order.

The storage device **108** can also include control circuitry **114**. The control circuitry **114** can be implemented as a controller, an electrical circuit, an integrated circuit, or as instructions executed by a processor associated with the storage device **108** or the data storage system **100**. In many embodiments, the control circuitry **114** can perform or coordinate one or more operations of the storage device **108** and/or data storage system **100**. For example, the control circuitry **114** can control the read and write head of the storage location **110**, can control the command queue **112**, and can send the responses **106** to the host device **102**.

In some embodiments, the control circuitry **114** can perform additional or fewer functions. For example, in certain embodiments, the control circuitry **114** can control the number of zones within the storage location **110** that are active and inactive.

FIG. **2** depicts a simplified block diagram of an example SMR data storage system **200** implementing multiple zones separated by guard bands, such as may be implemented by the storage location **110** of FIG. **1**. The SMR data storage system can be divided into N number of equally sized zones, each physically separated by a guard band. The size of the N zones and the size of the respective guard bands may vary from embodiment to embodiment. As illustrated each of the N zones is defined by twenty-two blocks to which data can be written.

The SMR data storage system **200** can also include a non-volatile memory **210** that can store information related to the N zones. For example, the non-volatile memory **210** can store a write pointer for each zone. In one embodiment, a write pointer can be a physical location within a particular zone that indicates a safe write location for subsequent write commands. For example, as noted above, an SMR system may be configured to write data sequentially. In many cases, a single write command may not write enough data to fill the entire zone. For example, as illustrated, ZONE 1 can be defined by twenty-two distinct blocks of data. As shown, only two of the twenty-two available blocks contain data (illustrated as shaded regions). Accordingly, the non-volatile memory **210** can store a write pointer **202** to record that the third block of ZONE 1 is the block from which subsequent write operations should begin. Similarly, ZONE 2 is illustrated containing three blocks of written data (illustrated as shaded regions). The write pointer **204** associated with ZONE 2 references the fourth block as the block from which subsequent write operations should begin. In addition, ZONE N is illustrated containing ten blocks of written data (illustrated as shaded regions). The write pointer **206** associated with ZONE N references the eleventh block as the block from which subsequent write operations may begin.

In addition, each individual zone can be configured to receive a write pointer reset command. As may be appreciated, resetting the write pointer of a particular zone to the beginning of the zone has the effect of erasing the data contained within the zone.

In many embodiments, an SMR data storage system **200** can perform one or more conditioning operations upon receiving or issuing a write pointer reset command for a particular zone. As noted above, the SMR data storage system **200** can physically inspect the zone to determine whether the zone has a defect **208**. For example, in certain embodiments and as noted above, a zone conditioning operation can include writing a particular pattern to one or more blocks within the selected zone. Thereafter, the pattern may be read back by the data storage system. The written and read patterns can be compared to determine whether the data was written correctly. In the event that the patterns do not match, the SMR data storage system **200** can store the detected defect **208** in the non-volatile memory **210**, so as to avoid writing to that location during future write operations.

In many cases, the written pattern can be used to facilitate discovery of the current write pointer of the SMR data storage system **200**. For example, in the case of power loss, the SMR data storage system **200** can read data from a particular zone or block and monitor for the known pattern that was previously written. Upon discovery of the location of the known pattern, the SMR data storage system **200** can update the write pointer associated with that zone to the location of the known pattern.

In other examples, other conditioning and/or maintenance operations can be performed. For example, some conditioning operations can determine whether a particular block or set of blocks or sectors within a particular block have failed. In these embodiments, the location of such failed blocks and/or sectors can be recorded such that the SMR data storage system **200** can prevent writing to the failed blocks during future write operations.

FIG. **3**A depicts a simplified block diagram of an example SMR data storage system implemented with a plurality of auxiliary zones. The SMR data storage system can include a magnetic recording disk divided into 2N writeable zones. These zones can be organized into several 'active' zones and several auxiliary 'inactive' zones.

The SMR data storage system can include a mapping table **302** that stores pointers for all active zones. As illustrated, the mapping table **302** can include pointers to ZONE 1-ZONE N. Similarly, an auxiliary zone queue **304** can store pointers for all inactive zones. As illustrated, the auxiliary zone queue **304** can include pointers to ZONE_AUX 1-ZONE_AUX N. In the illustrated embodiment, the SMR data storage system includes 2N zones; one half of the zones are active and referenced within the mapping table **302** and one half of the zones are inactive and referenced within the auxiliary zone queue **304**.

When the SMR data storage system receives a write instruction to one of the active zones, the SMR data storage system can substitute one of the inactive zones with the active zone to be written. Thereafter, the status of the substituted zones can be toggled; the previously-inactive zone can be set to an 'active' status and the previously-active zone can be set to an 'inactive' status.

For example, as shown in FIG. **3**B, if ZONE 1 receives a write instruction (e.g., write pointer reset command in FIG. **3**A), an auxiliary zone that is inactive, such as ZONE_AUX 1, can be selected to replace ZONE 1 within the mapping table **302**. Thereafter, ZONE 1 may be moved to the bottom of the auxiliary zone queue **304**. Next, the SMR data storage system can perform conditioning operations, such as those described herein, on the inactive zones within the auxiliary zone queue **304**. More particularly, the SMR data storage system can perform conditioning operations on ZONE 1.

In still further embodiments, such as the embodiment depicted in FIG. **3**C, more than one auxiliary zone queue can be used.

FIG. **4** depicts a flow chart of sample operations of a method of operating an SMR data storage system implemented with an auxiliary zone queue and a processing queue. A selected zone may be a member of mapping table of active zones at operation **402**. Thereafter, the SMR data storage system can set the selected zone to an inactive state and can pass the selected zone into a conditioning queue at operation **404**. In many examples, the SMR data storage system may pass the selected zone to the conditioning queue in response to a write instruction (e.g., write pointer reset command). In many examples, conditioning of the selected zone can take place while the SMR data storage system is idle.

Next, after the selected zone is conditioned within the conditioning queue, it can be passed to the auxiliary zone queue at operation **406**. At a later point, the selected zone can replace a second selected zone within the mapping table at **402**, by returning to active status.

FIG. **5** depicts a flow chart of sample operations of another method of operating an SMR data storage system implemented with auxiliary zones. The method can begin at operation **500** at which a write pointer reset instruction is received for ZONE 1 while the zone is in the active state (e.g., referenced by a mapping table).

Next, ZONE 1 can be set to an inactive state and can be pushed into an auxiliary zone queue at operation **502**. As with some embodiments described herein, one or more conditioning and/or maintenance operations can be performed on ZONE 1, when the zone is in the auxiliary zone queue.

Next, ZONE_TOP can be popped from the auxiliary zone cue at operation **504**. Once popped from the auxiliary zone queue, ZONE_TOP can be set to the active state and added to the mapping table.

FIG. **6** depicts a flow chart of sample operations of yet another method of operating an SMR data storage system implemented with auxiliary zones. The method can begin at operation **600** in which a write pointer reset command is received for a particular active zone. The selected zone may be set to an inactive state and can be passed immediately to a conditioning queue at **602**. Once in the conditioning queue, an inactive zone from the zone queue can be popped and added to the mapping table in the place of the selected zone at operation **604**.

Returning to the selected zone within the conditioning queue, the method may detect whether the selected zone is conditioned at **606**. If the zone is not conditioned (or needs to be conditioned and has yet to be conditioned), the method can continue to operation **608** during which the zone can be conditioned. However, if the zone is already conditioned (or does not need to be conditioned), the method can continue to operation **610** during which the zone is popped from the conditioning queue onto the zone queue.

In this manner, all members of the zone queue are fully conditioned prior to being added back to the mapping table at operation **604**.

FIG. **7**A-**7**B depicts a flow chart of sample operations of another method of operating an SMR data storage system implemented with auxiliary zones. The method of FIG. **7**A can begin at operation **700** at which a write pointer reset command is received for a first zone. Next, at operation **702**, the first zone is set to the inactive state. Next, at operation **704**, a second zone can be set to an active state. Finally, at operation **706**, the second zone may be substituted for the first zone within a mapping table associated with the SMR data storage system.

In many embodiments, the method of FIG. **7**A can be implemented by an SMR data storage device, such as depicted by the simplified flow chart of FIG. **7**B. As one example, the SMR data storage device can include a processor **710** that can perform or coordinate one or more of the operations of the SMR data storage device. The processor **710** can be connected to a voice coil motor **712** ("VCM") that controls the location of a read head and a write head along a rotatable disk **714** that is formed from a magnetic material. The processor **710** may also communicate with one or more host devices **708**.

The foregoing description, for purposes of explanation, used specific nomenclature to provide a thorough understanding of the described embodiments. However, it will be apparent to one skilled in the art that the specific details are not required in order to practice the described embodiments. Thus, the foregoing descriptions of the specific embodiments described herein are presented for purposes of illustration and description. They are not meant to be exhaustive or to limit the embodiments to the precise forms disclosed. It will be apparent to one of ordinary skill in the art that many modifications and variations are possible in view of the above teachings. In particular, any features described with respect to one embodiment may also be used in some embodiments, where compatible. Likewise, the features of the different embodiments may be exchanged, substituted, or omitted where compatible and appropriate.

Many embodiments of the foregoing disclosure may include or may be described in relation to various methods of operation, use, manufacture, and so on. Notably, the operations of methods presented herein are meant only to be exemplary and, accordingly, are not necessarily exhaustive. For example an alternate operation order, or fewer or additional steps may be required or desired for particular embodiments.

We claim:

1. A method for writing data to a data storage system, the method comprising:

receiving a reset command for a sequential write pointer of a first zone of a plurality of active zones defined in the data storage system, the first zone associated with a first pointer;

updating a status of a second zone not within the plurality of active zones to an active status; and

updating a status of the first zone to an inactive status.

2. The method of claim **1**, wherein the data storage system comprises a shingled magnetic recording system.

3. The method of claim **1**, further comprising conditioning the first zone after updating the status of the first zone to an inactive status.

4. The method of claim **3**, wherein conditioning the first zone comprises conditioning physical disk sectors.

5. The method of claim **3**, wherein conditioning the first zone comprises validating media defects associated with the first zone.

6. The method of claim **3**, wherein conditioning the first zone comprises managing relocation lists associated with the first zone.

7. The method of claim **3**, wherein conditioning the first zone is performed with the data storage system is in an idle state.

8. The method of claim **1**, further comprising:

releasing all write-relocated sectors of the first zone;

determining a plurality of write-relocated sectors are failing sectors; and

preventing future writes to the failing sectors.

9. The method of claim **8**, further comprising writing a known pattern to all write-relocated sectors that are not failing sectors.

10. The method of claim **1**, further comprising:

associated the first pointer with an auxiliary zone queue, the auxiliary zone queue comprising a plurality of pointers not within an active zone map;

removing from the auxiliary zone queue, a second pointer to a second zone, the second pointer from the plurality of pointers not within the active zone map; and

updating the zone map to replace the first pointer with the second pointer.

11. A data storage system comprising:

a data storage device; and

a controller configured to:

receive a reset command for a sequential write pointer of a first zone of a plurality of active zones defined in the data storage device, the first zone associated with a first pointer;

update a status of a second zone not within the plurality of active zones to an active status; and

update a status of the first zone to an inactive status.

12. The data storage system of claim **11**, wherein the data storage device comprises a shingled magnetic recording system.

13. The data storage system of claim **11**, wherein the controller is further configured to condition the first zone after updating the status of the first zone to an inactive status.

14. The data storage system of claim **13**, wherein the controller is further configured to condition the first zone by conditioning physical disk sectors.

15. The data storage system of claim **11**, wherein the controller is further configured to validate media defects associated with the first zone.

16. The data storage system of claim **11**, wherein the controller is further configured to manage relocation lists associated with the first zone.

17. The data storage system of claim **11**, wherein conditioning the first zone is performed with the data storage system is in an idle state.

18. The data storage system of claim **11**, wherein the controller is further configured to:

release all write-relocated sectors of the first zone;

determine a plurality of write-relocated sectors are failing sectors; and

prevent future writes to the failing sectors.

19. The data storage system of claim **18**, further comprising writing a known pattern to all write-relocated sectors that are not failing sectors.

20. A controller for managing a data storage device associated with a data storage system, the controller configured to:

receive a reset command for a sequential write pointer of a first zone of a plurality of active zones defined in the data storage device, the first zone associated with a first pointer;

update a status of a second zone not within the plurality of active zones to an active status; and

update a status of the first zone to an inactive status.

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